Astrophysics and Twentieth-Century Astronomy to 1950. Owen Gingerich

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if others find here some material which will be either useful or stimulating in such studies" (p. xi). This latter hope will not be disappointed. Marie Boas Hall deserves our thanks for turning her talents to the task.

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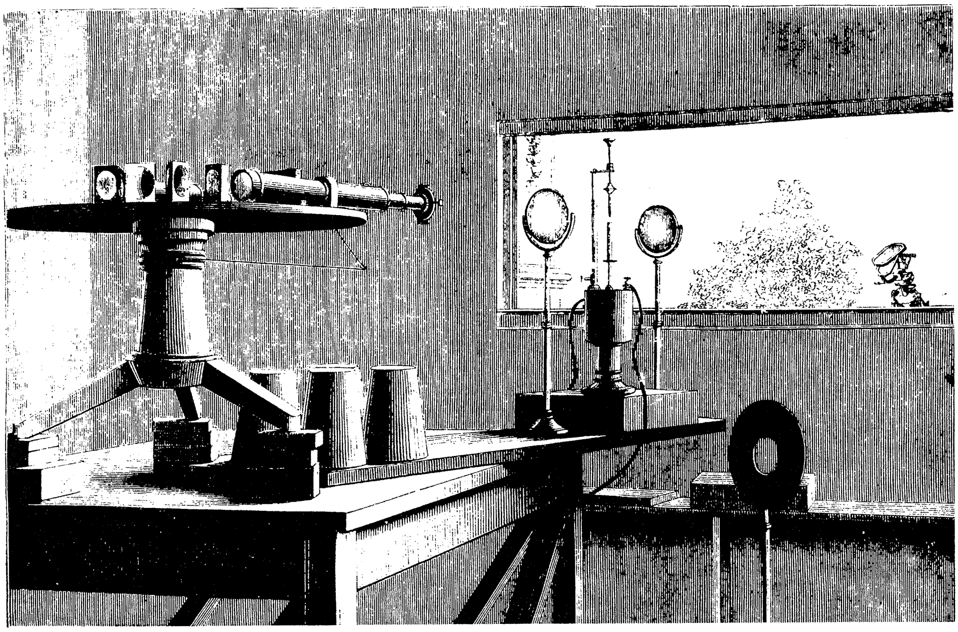
Star quality

Owen Gingerich (Editor). *Astrophysics and Twentieth-Century Astronomy to 1950*. (The General History of Astronomy, 4a.) xi + 198 pp., illus., app., index. Cambridge/London/New York: Cambridge University Press, 1984. $29.95.

The project to produce the General History of Astronomy, of which this volume forms a part, was set in motion in 1972 under the protective wings of the International Astronomical Union and the International Union for History and Philosophy of Science. The series is a cooperative venture to which some scores of historians of astronomy are giving their services, and it has the strengths and weaknesses of all such ventures. That this first volume has cohesion in good measure is due very largely to a resolute editor, and what it lacks in cohesion it more than recovers through the great variety of its contributors' perspectives—which are by no means restricted to those of the professional historian and do not seem unduly distorted as a result. The work is meant to offer an authoritative synthesis to "a wider readership," which is to say, to anyone inclined to use it. Its editors—and I might mention that the general editor is Michael Hoskin—are rather unclear as to whom exactly they have in mind, but this volume makes easy reading, and there is no doubt whatever that it will find a good home in almost any library where the physical sciences are represented.

The volume falls into two parts: the birth of astrophysics from about 1850 to 1920 is followed by a less well structured account of observatories and instrumentation that covers a somewhat longer period. (Part B, we are told in advance, will cover modern astrophysics, the structure of the universe from 1900 to 1950, and the "sociology of astronomy"—the structure of the society that determines the structure of the universe.) A. J. Meadows opens the first section with the origins of astrophysics and conveys very effectively a feeling of what it was to be in at the beginning of a subject that was virtually new in its entirety, a feeling that it is given to few to experience. Symbolic of the chapter as well as of the volume is the first photograph, of Robert Bunsen, Gustav Kirchhoff, and Henry Roscoe (worth mentioning because it is typical of all the illustrations in the volume in being of good quality and apt but not hackneyed). Kirchhoff's extremely fertile imagination led to a succession of solar models but was always held in check by new observations. Not that such constraints knocked the excitement out of the game for anyone, for the intricate solar spectrum alone must have created the impression on these pioneers that a vast sweet shop makes on a small child. The subject had truly come of age when Pierre Janssen and Norman Lockyer could preempt laboratory physics with the discovery of the helium line.

Astronomical photography in general has more spectacular scenes to display than spectrographs, of course, and the spectacle came early. John Lankford's chapter on the subject shows how the diffusion of photographic technology



Apparatus for comparing solar and laboratory spectra as depicted by Norman Lockyer, 1887. From Astrophysics and Twentieth-Century Astronomy to 1950.

through the international community came relatively easily, in three generations or so. Here the interactions of amateur work with professional are still very much in evidence—astronomy is fairly unusual in that even now there are odd corners of the subject where the role of the amateur is not insignificant. In his study of telescope building from 1850 to 1900, Albert van Helden again underscores the role of the wealthy amateur, without whose help the race to produce bigger and better instruments would have been run at a much slower pace. The days of the Birr Castle style were numbered, though, and professional observatories were going over to refractors for most of this period: Pulkovo, Harvard, Washington, Vienna, Yerkes. There was competition, to be sure, but it all reads like a gentlemanly version of the arms race of our own time. The results—for those with quiet tastes—were even so almost as spectacular, and the photograph of solar granulation, pores, and sunspots taken by Janssen at Meudon just a hundred years ago might well stand as a symbol of the spectacle. As a photograph of that particular phenomenon, it was without equal almost until our own time.

As A. J. Meadows points out in another chapter, on the new astronomy, astrophysics in the nineteenth century "required practical ingenuity and a willingness to travel, without need for a deep involvement in mathematics." For these reasons—and others—there was an especially rapid growth of the subject in the United States. Helen Sawyer Hogg's chapter on variable stars highlights one of the most successful of American (in this case mostly Harvard) enterprises, in which women, a New World within a New World, played some of the most distinguished parts. She includes an intriguing photograph of a meeting of the American Association of Variable Star Observers held at Harvard in 1917 that includes Leah Allen, Annie J. Cannon, and Henrietta S. Leavitt, all of them well worthy of pedestals (if that were not now regarded as a sexist concept) for their parts in settling distance criteria so necessary to the charting of the universe. Not that one should forget the many other implications of their work. It was almost a necessary condition of the subsequent study of the physical properties of the Cepheid variables and of the relations between fluctuations in light and velocity in eclipsing variables; and these later studies in turn provided much-needed information about the densities and sizes of stars, and so, indirectly, of others among their physical properties.

One of the marks of good editing by Owen Gingerich, its unobtrusiveness apart, is that it has resulted in an almost seamless fabric. One essay slides fairly naturally into the next with a minimum of duplication or other redundancy. David Devorkin's chapter on stellar evolution and the origin of the Hertzsprung-Russell diagram introduces us to a rather more professional bunch of physicists than we meet in many of the other chapters, but even here we have Norman Lockyer—who like many of the stars is difficult to classify, but who certainly began at the amateur end of the spectrum. How annoying, to the scientific establishment, to be told that atoms might be destructible and that an element might have more than one spectrum! The Harvard spectral classification, like so much of the work that stemmed from it, has a scientific quality reminiscent of much of Darwin's work on the animal kingdom: a feeling for what belonged where in the natural order was as important in those pioneer days as being able to write and solve partial differential equations.

The second half of the volume, on observatories and instrumentation, contains what has traditionally been the Cinderella of scientific history and left well out of sight. The Mona Lisa's face is for most of us more interesting than her skeleton would be, but it is as well to remember from time to time that the one is propped up by the other. Instruments are in some respects the skeletons that support Great Ideas. A century ago, as Owen Gingerich reminds us, 150 of the 200 most important observatories in the world were in Europe and 42 in North America. Naturally not all of these can be discussed, but a goodly proportion get some sort of mention and there are some useful out-of-the-way photographs and other illustrations. In Europe it had long been the case that governments footed the bill, at least at the highest institutional levels—at Greenwich, Paris, Pulkovo, Potsdam, for example. In the United States, out of the list of the six foremost institutions —Harvard, U.S. Naval Observatory, Lick, Yerkes, Mount Wilson, Mount Palomar—only one was a result of national funding. How were their cognitive fortunes related to the sources of their financial backing? There are materials for this intricate socioeconomic subject here in plenty, but the contributors to the volume are not sociologists of knowledge, amateur or professional, and have left it to the reader to explore this, the fifth dimension of the universe. At the risk of venturing into these deep waters, I will confine myself to the observation that there is a law operating according to which the greater the distance from government, the less boring the work done.

There are thumbnail sketches here by a number of local experts of many of the great observatories. Albert van Helden considers the building of large telescopes in a chapter photographically and descriptively impressive, and David Evans takes charge of telescopes in the all-too-often neglected southern hemisphere. Not least among the book's virtues is an appendix by Barbara L. Welther on the world's largest telescopes from 1850 to 1950, with invaluable tables of reflectors and refractors listing their sizes, places, builders, dates, and observatories. No prizes are offered for those who, having read the book up to this point, are unable to resist the temptation to turn the tables into graphical form and thus take the mandatory first step on the road to a sociology of the telescope.

There is at the end a slight loss of synchronization with the earlier part of the volume, in that chapters by Charles Fehrenbach, Herbert Friedman, and Woodruff T. Sullivan III cover twentieth-century instrumentation well beyond the 1920 mark. Between them, they lead us out of the visible part of the spectrum through photography and electronic photometry, bolometry, and polarimetry into the ultraviolet, infrared, and radio regions. Here radio and rockets are on the bill, with the star of the show, as some would now see it, being the discovery of galactic 21-centimeter radiation from neutral hydrogen. These chapters are enjoyable, for all they seem a little lonely in their present company. They act as a tailplane, guiding us into Part B with a sense of pleasurable anticipation.

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Optical profusion

Isaac Newton. *The Optical Papers of Isaac Newton.* Edited by **Alan E. Shapiro.** Volume I: *The Optical Lectures, 1670–1672.* xix + 627 pp., illus., bibl., index. Cambridge/London/New York: Cambridge University Press, 1983. $135.

> It was as long ago as the Year 1666, when Sir *Isaac Newton* first found out his Theory of Light and Colors. Upon Dr *Barrow's* resigning to him the Professorship of the Mathematicks at Cambridge, he made A. 1669, this Discovery the Subject of his publick Lectures in that University. In 1671 he began to communicate it to the World, as also a Description of his Reflecting Telescope, in the *Philosophical Transactions.* About the same time he intended to publish his Optical Lectures, wherein these Matters were handled more fully; together with a Treatise of Series and Fluxions. But the Disputes, which were occasioned, by what he had already suffered to come abroad, deterred him from that Design. And hence he conceived so great an Horror for anything, that looked like Controversy, that the constant Importunities of his Friends could not prevail upon him to print his Book of Optics until the Year 1704. As to his Lectures, they were deposited, at the time they were read, among the Archives of the University. From whence many Copies have been taken, and handed about by the Curious in these Matters.

This, from the preface to the English edition (1728) of the *Optical Lectures,* is a nearly correct account of the origin and fate of Newton's first large work. Recent scholarship has modified it in some particulars. According to Newton's own account in the "New Theory about Light and Colors" (1672), in the beginning of 1666, while attempting to grind nonspherical lenses, he procured a triangular glass prism "to try therewith the celebrated *Phaenomena* of *Colours.*" He passed a narrow beam of sunlight through the prism in a darkened room, and noted that the colors thrown upon the opposite wall were of an oblong form, the length about five times the breadth, although according to the received laws of refraction, he expected them to be circular. This observation marked the beginning of a remarkable series of experiments demonstrating most notably that "*Light* consists of *Rays differently refrangible,*" that "to the same degree of Refrangibility ever belongs the same color," and that white "Light is a confused aggregate of Rays indued with all sorts of Colors."

All of this—"the oddest if not the most considerable detection w^{ch} hath hitherto beene made in the operations of Nature"—is well known, for one may reasonably suppose that these are the most famous experiments ever performed. It is equally well known, and for the most part true, that as a result Newton